HYDROLOGIC RESOURCE MONITORING PARAMETERS

Groundwater Level

Brief Description: Groundwater is replenished from precipitation and from surface water, but the rate of abstraction (withdrawal by humans) may exceed the rate of natural recharge, leading to reduction of the resource. Some aquifers, especially in arid and semi-arid regions, contain paleowaters (fossil groundwater) stored from earlier periods of wetter climate: the reduction of these reserves is comparable to 'mining'. In alluvial plains, reduction in streamflow reduces the rate of natural recharge to aquifers: in Bangladesh it is estimated that local groundwater levels have dropped nearly 3 m because of upstream dams and diversions of the Ganges. Measurement on a regular basis of water levels in wells and boreholes or of spring discharge provides the simplest indicator of changes in groundwater resources. However, springs may be perennial, intermittent, or periodic, and their discharge may depend on changes in climate, tides, and local underground conditions such as changes in rock stresses.

Significance: Groundwater is the major source of water in many regions, supplying a large proportion of water globally. In the USA, more than half the drinking water comes from the subsurface: in arid regions it is generally the only source of water. The availability of clean water is of fundamental importance to the sustainability of life. It is essential to know how long the resource will last and to determine the present recharge: groundwater mining is a terminal condition.

Environment where Applicable: Wherever groundwater is extracted for human use (drinking, irrigation, industrial use), or where it influences the ecosystem (e.g. in wetlands). Paleowaters are of particular importance in aquifers in arid and semi-arid regions.

Types of Monitoring Sites: Boreholes, wells or springs representative of the particular aquifer.

Method of Measurement: Monitoring of the depth to the water table is carried out using manual measurements, automatic water-level recorders, or pressure transducers. Standard hydrogeological methods are used to calculate a water balance. Current recharge rates must be calculated taking account of climatic variability over recent decades.

Frequency of Measurement: Minimum monthly intervals to reflect seasonal as well as annual changes. The state of fossil aquifers should be assessed at about 5-year intervals.

Limitations of Data and Monitoring: Water levels need to be measured both seasonally and annually over decades to determine overall trends. Overall accuracy of manual methods is around 1 cm, but this can be reduced to millimeters with automation.

Possible Thresholds: A threshold is crossed when the rate of abstraction exceeds the rate of recharge, and a sustainable renewable resource becomes a non-renewable mined one. When pumping a well exceeds the rate of lateral inflow, the well dries out and a threshold has been crossed, though the situation may reverse itself when pumping ceases or when recharge increases.

Key References:

Edmunds, W.M. 1996. Indicators in the groundwater environment of rapid environmental change. In Berger, A.R. & W.J.Iams (eds). Geoindicators: Assessing rapid environmental changes in earth systems:121-136. Rotterdam: A.A. Balkema.

Freeze, R.D. & J.A. Cherry 1979. Groundwater. Englewood Cliffs, NJ: Prentice-Hall.

deMarsily, G. 1986. Quantitative hydrology. New York: Academic Press.

Price, M. 1985. Introducing groundwater. London: Allen and Unwin.

Related Environmental and Geological Issues: There is an extensive 'agenda' of environmental issues related to groundwater depletion, including the drainage of wetlands, stability of foundations, and the salinization of soils [see groundwater quality]. Pollution of groundwater, a major problem in urban areas, also reduces the overall resource.

Overall Assessment: The level of groundwater is an essential parameter in areas of groundwater use.

Source: This summary of monitoring parameters has been adapted from the Geoindicator Checklist developed by the International Union of Geological Sciences through its Commission on Geological Sciences for Environmental Planning. Geoindicators include 27 earth system processes and phenomena that are liable to change in less than a century in magnitude, direction, or rate to an extent that may be significant for environmental sustainability and ecological health. Geoindicators were developed as tools to assist in integrated assessments of natural environments and ecosystems, as well as for state-of-the-environment reporting. Some general references useful for many geoindicators are listed here:

Berger, A.R. & W.J.Iams (eds.) 1996. Geoindicators: assessing rapid environmental change in earth systems. Rotterdam: Balkema. The scientific and policy background to geoindicators, including the first formal publication of the geoindicator checklist.

Goudie, A. 1990. Geomorphological techniques. Second Edition. London: Allen & Unwin. A comprehensive review of techniques that have been employed in studies of drainage basins, rivers, hillslopes, glaciers and other landforms.

Gregory, K.J. & D.E.Walling (eds) 1987. Human activity and environmental processes. New York: John Wiley. Precipitation; hydrological, coastal and ocean processes; lacustrine systems; slopes and weathering; river channels; permafrost; land subsidence; soil profiles, erosion and conservation; impacts on vegetation and animals; desertification.

Nuhfer, E.B., R.J.Proctor & P.H.Moser 1993. The citizens' guide to geologic hazards. American Institute for Professional Geologists (7828 Vance Drive, Ste 103, Arvada CO 80003, USA). A very useful summary of a wide range of natural hazards.